AMENDMENTS TO THE CLAIMS

1. (Currently amended) An integrated optical apparatus, comprising:

a planar waveguide having an elongate guiding portion and a grating coupler, said coupler having at least a flared waveguide portion comprising a relatively narrow end portion and a relatively wide end portion, said flared portion comprising at least one curved sidewall for guiding the propagation of light in said flare portion, said curved sidewall having a curvature defined by a substantially hyperbolic path, wherein said flared portion has a grating positioned to couple light between said coupler and an optical element that is located above said planar waveguide.

2. (Original) The integrated optical apparatus of claim 1, wherein said grating comprises curved elongate scattering elements.

3. (Original) The integrated optical apparatus of claim 2, wherein said curved elongate scattering elements have a curvature defined by substantially elliptical paths defined by a pair of foci.

4. (Original) The integrated optical apparatus of claim 2, wherein said curved elongate scattering elements have a curvature defined by substantially circular paths.

5. (Original) The integrated optical apparatus of claim 1, wherein waveguide grating coupler has a coupling efficiency of at least about 50%.

6. (Original) The integrated optical apparatus of claim 1, wherein said optical element comprises an optical fiber.

7. (Original) The integrated optical apparatus of claim 1, wherein said flared portion comprises two sides curved to support the guided propagation of circularly cylindrical wavefronts in said flared portion.

8. (Original) The integrated optical apparatus of claim 1, wherein said elongate guiding portion has a numerical aperture and said flared portion has sides that flare out at angles that define a numerical aperture for said flared portion, said numerical aperture of said flared portion being smaller than said numerical aperture corresponding to said elongate guiding portion.

9. (Original) The integrated optical apparatus of claim 1, wherein said grating comprises elongate scattering elements having a spacing selected to provide a desired angle of

propagation of said light coupled between said waveguide grating coupler and said optical element.

10. (Original) The integrated optical apparatus of claim 1, wherein said sidewall ranges up to about 1000 micrometers in length along a side.

11. (Original) The integrated optical apparatus of claim 10, wherein said relatively wide end portion ranges up to about 500 micrometers wide.

12. (Original) The integrated optical apparatus of claim 11, wherein said relatively narrow end portion ranges up to about 20 micrometers wide.

13. (Original) The integrated optical apparatus of claim 1, wherein said flared portion comprises sidewalls each having a length, and said wide end portion has a width, said length of said sidewalls substantially matching the width of said wide end portion.

14. (Original) The integrated optical apparatus of claim 13, wherein said wide end portion is about 30 micrometers wide and said sidewalls have a length of about 30 micrometers along a side.

15. (Currently amended) The integrated optical apparatus of claim 1, wherein said ~~waveguide~~ grating coupler is selected from the group consisting of a slab waveguide, a strip loaded waveguide, a channel waveguide, and ridge waveguide.

16. (Currently amended) The integrated optical apparatus of claim 1, wherein said ~~waveguide~~ grating coupler comprises a strip loaded waveguide comprising a strip, a slab, and a low index transition layer between said strip and said slab.

17. (Currently amended) The integrated optical apparatus of claim 1, wherein said ~~waveguide~~ grating coupler comprises silicon.

18. (Currently amended) The integrated optical apparatus of claim 17, wherein said ~~waveguide~~ grating coupler comprises silicon oxide.

19. (Currently amended) An integrated optical apparatus, comprising:

a planar waveguide having an elongate guiding portion and a grating coupler, said coupler having at least a flared waveguide portion comprising a relatively narrow end portion and a relatively wide end portion, said flared portion having a grating positioned thereon to couple light between said coupler and an optical element that is located above said grating;[[,]]

wherein said grating comprises curved elongate scattering elements having curvatures defined by substantially elliptical paths so as to couple plane waves between said ~~waveguide~~ grating coupler and said optical element.

20. (Original) The integrated optical apparatus of claim 19, wherein said flared portion comprises two sides curved to support the guided propagation of circularly cylindrical wavefronts in said flared portion.

21. (Original) The integrated optical apparatus of claim 19, wherein said elongate guiding portion has a numerical aperture and said flared portion has sides that flare out at angles that define a numerical aperture for said flared portion, said numerical aperture of said flared portion being smaller than said numerical aperture corresponding to said elongate guiding portion.

22. (Original) The integrated optical apparatus of claim 19, wherein waveguide grating coupler has a coupling efficiency of at least about 50%.

23. (Original) The integrated optical apparatus of claim 19, wherein said optical element comprises an optical fiber.

24. (Original) The integrated optical apparatus of claim 19, wherein said sidewall ranges up to about 1000 micrometers in length along a side.

25. (Original) The integrated optical apparatus of claim 19, wherein said relatively wide end portion ranges up to about 500 micrometers wide.

26. (Original) The integrated optical apparatus of claim 19, wherein said relatively narrow end portion ranges up to about 20 micrometers wide.

27. (Original) The integrated optical apparatus of claim 19, wherein said flared portion comprises sidewalls each having a length, and said wide end portion has a width, said length of said sidewalls substantially matching the width of said wide end portion.

28. (Currently amended) The integrated optical apparatus of claim 19, wherein said ~~waveguide~~ grating coupler is selected from the group consisting of a slab waveguide, a strip loaded waveguide, a channel waveguide, and ridge waveguide.

29. (Currently amended) The integrated optical apparatus of claim 19, wherein said ~~waveguide~~ grating coupler comprises a strip loaded waveguide comprising a strip, a slab, and a low index transition layer between said strip and said slab.

30. (Currently amended) The integrated optical apparatus of claim 19, wherein said ~~waveguide~~ grating coupler comprises silicon.

31. (Currently amended) The integrated optical apparatus of claim 19, wherein said ~~waveguide~~ grating coupler comprises silicon oxide.

32. (Original) The integrated optical apparatus of claim 19, further comprising a substrate, said planar waveguide disposed over said substrate.

33. (Original) The integrated optical apparatus of claim 32, wherein said substrate comprises a silicon wafer.

34. (Original) The integrated optical apparatus of claim 33, wherein said substrate further comprises a silicon dioxide layer formed on said silicon wafer.

35. (Original) The integrated optical apparatus of claim 33, wherein said substrate further comprises one or more layers of material formed on said silicon wafer.

36. (Original) An optical system, comprising:

an optical fiber; and

an integrated optical circuit having a waveguide, said waveguide comprising a waveguide grating coupler which propagates light having non-planar wavefronts and couples light having planar wavefronts between the grating coupler and the optical fiber,

wherein said fiber has an end in the near field of the grating coupler, said grating coupler has elongate scattering elements within the Rayleigh range of the fiber end, and said elongate scattering elements are curved to convert wavefronts of light between planar wavefronts and non-planar wavefronts.

37. (Original) The optical system of claim 36, wherein said waveguide comprises a planar waveguide having sidewalls to confine light in a transverse direction.

38. (Original) The optical system of claim 37, wherein said waveguide is selected from the group consisting of a channel waveguide, a ridge waveguide, a strip loaded waveguide, and a strip loaded waveguide having a low index transition region.

39. (Original) The optical system of claim 37, wherein said waveguide comprises a shaped portion wherein said sidewalls are separated by different amounts along said waveguide such that light propagating therein has non-planar wavefronts.

40. (Original) The optical system of claim 39, wherein said shaped portion of said waveguide is flared, said sidewalls being separated by an increasingly larger amount from a narrow end of said shaped portion to a wide end of said shaped portion.

41. (Original) The optical system of claim 36, wherein said curved elongate scattering elements have a concave side facing said narrow end of said waveguide.

42. (Original) The optical system of claim 36, wherein said elongate scattering elements have curvatures defined by substantially elliptical paths.

43. (Original) The optical system of claim 36, wherein said optical fiber comprises a single mode fiber.

44. (Original) The optical system of claim 36, wherein said waveguide has a geometry that supports a single optical mode.

45. (Original) The optical system of claim 36, wherein said waveguide has a geometry that supports a single polarization.

46. (Original) The optical system of claim 36, wherein said optical fiber comprises a core having a cross-section and said waveguide has a height and width defining a cross-section, said cross-section associated with said core of said optical fiber being substantially larger than said cross-section defined by said width and height of said waveguide.

47. (Original) The optical system of claim 36, wherein said optical fiber and said waveguide have respective numerical apertures, and said numerical aperture of said waveguide is substantially larger than said numerical aperture of said optical fiber.

48. (Original) The optical system of claim 36, wherein said waveguide grating coupler comprises silicon and silicon dioxide.

49. (Original) The optical system of claim 36, wherein said coupling efficiency of said waveguide grating coupler is about 50%.

50. (Original) The optical system of claim 36, wherein said optical fiber comprises a core, said waveguide has a width and height, and said grating coupler has a length, and wherein said core of said optical fiber has a transverse dimension that is at least twenty times as large as said width of said waveguide and said length of said grating coupler.

51. (Original) The optical system of claim 36, wherein said elongate scattering elements have widths that vary to convert wavefronts of light between planar wavefronts having

a Gaussian intensity profile in the near field and non-planar wavefronts within the waveguide grating coupler.

52. (Original) The integrated optical apparatus of claim 36, wherein said elongate scattering elements have a curvature defined by substantially circular paths.